

## **CAN CONSUMER COMPLAINTS REDUCE PRODUCT RELIABILITY? SHOULD WE WORRY?**

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**SERIE DOCUMENTOS DE TRABAJO**

**No. 149**

**Diciembre de 2013**

# Can Consumer Complaints Reduce Product Reliability? Should We Worry?

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December 2013

## Abstract

We analyze a monopolist's pricing and product reliability problem when consumers are entitled to product replacement but have heterogeneous cost of exercising this right, and we assess the implications of a decrease in consumers' claiming cost on reliability, profit, and welfare. We find that reducing consumers' claiming cost may reduce reliability and increase profit. Additionally, the model can explain why some firms encourage consumers to complain while others discourage consumers from complaining. We also show that welfare and profit are partially aligned, specially when consumers' claiming cost are relatively low and the firm prefers to promote complaints; consequently, we find that encouraging complaints will eventually increase welfare.

*Keywords:* product reliability, consumer complaints, liability cost, warranty.

*JEL Classification:* K41, D42, D21, L10.

## 1 Introduction

In their dealings with retailers and suppliers, regulations and warranties ensure that consumers can seek a repair, a replacement, or a refund if the good they have purchased is faulty (Mann and Wissink, 1990). The evidence, however, indicates that many consumers do not pursue any form of compensation (Andreasen and Best, 1977; Huppertz, 2007), suggesting that, for some consumers, claiming costs are high (Huppertz, 2007; Hirschman, 1970). In the last decades, there have been several initiatives helping consumers channel their complaints. At the same time, a firm may have incentives to reduce reliability when

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few consumers complain about faulty units. In this article, we analyze a monopolist's pricing and product reliability problem when consumers are entitled to product replacement and we assess the implications of a decrease in consumers' claiming cost. Our results suggest that product reliability may decrease whereas firm's profit and welfare may increase after a reduction of consumers' claiming cost.

There are several facts reflecting that it is becoming easier for consumers to engage in claims when receiving faulty units. First, consumer's rights are constantly improving.<sup>1</sup> Second, there are several mechanisms that simplify complaints: small courts, class action lawsuits, public agencies (e.g., NHTSA in the US) and consumer associations (claiming on consumer's behalf). Third, information and communication technologies (ICT) provide new tools that simplify complaining and allow private enterprises to help consumers channel their complaints.<sup>2</sup> For instance, "getsatisfaction.com" in the US provides a service to handle complaints and mediate between consumers and firms. Similarly, "miqueja.com" in Spain publishes consumer's complaints and firms' responses, ranking firms according to the number of complaints received and the responses that firms provide to them. Finally, it is also getting important for firms to handle correctly consumer complaints: more than 40,000 firms use "getsatisfaction.com" in the US.<sup>3</sup>

To study the effect of a reduction in the consumers' claiming cost on the firm's decisions, we construct a model with a monopolist choosing the price and the reliability of the product it manufactures. The product's reliability is defined by the probability that it is not defective. Providing a more reliable product and replacing a faulty unit are costly actions for the firm. Consumers derive a high utility from consuming a product that does not break down and a low utility otherwise. If a product is faulty, the consumer chooses whether to seek a replacement incurring a cost. Consumers differ in their claiming cost. Within this set-up, our aim is to understand the impact of a decrease in consumers' claiming cost (e.g., moving downward the distribution of consumers' claiming cost) on reliability, firm's profit, and welfare.

Consumers anticipate the expected future cost associated with defective units when calculating their willingness to pay. We define the *demand effect* as the effect of increasing reliability on consumers' willingness to pay. The higher the consumers' claiming cost, the lower the willingness to pay but the higher the demand effect, as it is more costly for a consumer to request a replacement (when he does it) and it is more likely that the consumer scraps defective units.

We first show that product's reliability may decrease when consumers' claiming cost decreases. Given a consumers' claiming cost, the firm's choice of reliability faces the following trade-off: increasing reliability is costly but increases the willingness to pay of consumers (*demand effect*) and decreases the firm's expected cost of replacements (labeled *replacement effect*). A reduction in consumers' claiming

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<sup>1</sup>In 1962, Kennedy's Administration in the US introduced the first consumer's rights: Safety, Choose, Be Informed, and Be Heard. Another rights were included in 1985: Satisfaction of Basic Needs, Redress, Consumer Education, and Healthy Environment. These rights spread fast to most countries. More rights are constantly improving consumer conditions.

<sup>2</sup>Car-related complaints at the National Highway Traffic Safety Administration (NHTSA) rose from dozens to thousands when it incorporated the e-mail and the website platform to file complaints in 1995.

<sup>3</sup>Among these firms you find Procter and Gamble (Pampers), Microsoft, Panasonic, and Amazon. It is also worth noting that most sales incorporates explicit and implicit warranties and firms usually stick to them.

cost both increases the replacement effect and decreases the demand effect. We prove that there always exists a reduction in consumers claiming cost where the reduction in the demand effect dominates, and thus, reliability decreases. The situation where reliability decreases is more likely when consumers' claiming cost is low enough.

Secondly, we show that firm's profit may increase or decrease when consumers' claiming cost decreases. When there is a reduction in consumers' claiming cost, firm's profit is also affected by two opposite effects. Consumers' willingness to pay increases but also consumers are more likely to request replacements, increasing the expected costs associated with replacements. We prove that there always exists a reduction in consumers claiming cost where the former effect dominates, and thus, markups and profit increase. Otherwise, markups and profit decrease. The situation where profit increases is more likely when consumers' claiming cost is low enough.

We prove these results in two different setups. Our benchmark model analyzes the case in which each consumer does not know his claiming cost before purchasing, that is, he knows his claiming cost only after receiving a faulty unit. Then, we extend the model for the case in which each consumer privately knows his claiming cost before deciding whether to purchase the product or not, and we allow for price discrimination. A contribution of this extension –more technical– is to provide one example where a bunching strategy for price discrimination arises due to an (endogenous) discontinuity in the Virtual Surplus under regular conditions (Mussa and Rosen, 1978; Lewis and Sappington, 1989; Rochet and Choné, 1998; Jullien, 2000).

Finally, under mild assumptions over consumers' claiming cost distributions, we show that firm's profit and social welfare are aligned. We find that if consumers' claiming cost is low enough, a further reduction in it will likely increase profit and welfare and reduce product's reliability. This result is more general for the benchmark case.

The anecdotal evidence reveals that, indeed, both firms and third parties (consumer agencies, etc.) can partially affect consumer complaints, a possibility that we rule out in the model. To link this evidence with our model, we show that, if a firm were allowed to make an exogenous and local change in consumers' claiming cost, it will prefer to discourage consumers from complaining only if consumers' claiming cost is high enough; otherwise it will prefer to encourage consumers to complain. Consistent with our implications, interventions that successfully reduced consumers' claiming cost have been first proposed by legislators and consumer agencies –like the US experience from the 1960s onwards– supported mainly by consumer movements. More recently, many firms have found worthy to simplify complaints even further, for instance, channeling complaints through private on-line initiatives. Moreover, our results suggest that these firms' interventions may increase social welfare even when they may be reducing their products' reliability.

Our results are robust to different specifications: 1) if the firm replaces defective units with probability lower than 1 when requested; 2) if product reliability is a function of expenditures in product design, keeping constant the manufacturing cost; 3) if there is heterogeneity in consumers' claiming cost and/or

in consumer's valuations; and 4) if there is correlation between consumers' claiming cost and consumer's valuations.

The article is structured as follows. In Section 2 we review the literature. In Section 3 we introduce the model. In Section 4 we analyze the case in which each consumer does not know his claiming cost before purchasing. In Section 5 we extend for the case in which each consumer knows his claiming cost before deciding whether to purchase the product or not. In Section 6 we describe different possible specifications of the model. Finally, in Section 7 we conclude. All proofs are in the Appendix.

## 2 Related Literature

Our article relates to two strands of the literature. First, the literature on product liability. When consumers perfectly observe product reliability, a change in product's liability from consumer to producer can affect quality negatively (Oi, 1973). Under firm's liability, there may exist a non-monotonic relation between (the degree of) product liability and the ex-ante investment to improve reliability when the firm may take preventive ex-post solutions, e.g., recalls, (Chen and Hua, 2012). However, these approaches assume that it is costless for consumers to complain when the product fails. Indeed, Simon (1981) recognizes that costly litigation motivates the existence of negligent firms when there is imperfect information about product reliability and the outcome of a lawsuit. In her environment, a reduction in consumers' litigation cost always promotes firms to increase product reliability. However, that approach binds consumers to buy one unit of the product, eliminating the demand effect which drives our non-monotonic result.<sup>4</sup> Hua (2011) also introduces a cost for consumers to recall a defective product when analyzing the firm's incentives to make a recall under alternative liability settings. However, he assumes that quality is exogenous and consumers have already purchased the product.

Our article also relates to the vast literature on warranties as an exploitation device.<sup>5</sup> To cite just a few articles, Mann and Wissink (1990), Matthews and Moore (1987), Murthy and Djamaludin (2002), Huang, Liu, and Murthy (2007) analyze how warranties may affect the firm's choice of product reliability and the demand. Again, these articles assume that it is costless to exercise a warranty or a consumer right.<sup>6</sup> An exception is Palfrey and Romer (1983) that study the relation between the optimal warranty and buyer-seller disputes. However, they assume that consumers are homogeneous and that product reliability is exogenous.<sup>7,8</sup>

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<sup>4</sup>In Shavell (2007) there are other important aspects of product liability for accidents.

<sup>5</sup>Emons (1989) classifies the literature on warranties according to its purpose in exploitation, to increase consumers' willingness to pay, signaling, to reveal product reliability, and incentive, to increase quality conditions. See also Priest (1981) for an investment approach.

<sup>6</sup>Most results that link warranty conditions and product reliability (including those results on the signaling approach of warranties) relies on the fact that consumers exercise their guarantees and that consumers' claiming cost is almost null.

<sup>7</sup>There are other mechanisms to motivate a provision of reliability based on repeated purchases, reputation, cooperation and brand name (Klein and Leffler, 1981; Greif, Milgrom, and Weingast, 1994). In our static environment, however, these mechanisms play no role in guaranteeing the provision of product reliability.

<sup>8</sup>Our article also relates to the literature on consumers' complaint behavior (CCB), which focuses on the consumers' reaction

### 3 Model

There is a unit mass of consumers who makes two sequential decisions; first, whether to purchase one unit of the product with price  $p$  and reliability rate  $x$ , and, second, whether to pursue a replacement if the product breaks down.<sup>9</sup> A consumer derives utility  $v > 0$  from consuming one unit of a non-faulty good. If the good is faulty or the consumer chooses not to purchase it, he derives a utility of 0. If the consumer requests a replacement, he incurs in a claiming cost  $k \in [0, +\infty)$  that comes from cumulative distribution  $F$ . Heterogeneity in  $k$  may lead to some consumers scrapping faulty products.

On the supply side, a monopolist chooses its product's price  $p$  and reliability rate  $x \in [0, 1]$  to maximize its profit, anticipating that consumers may request a replacement if the product they have purchased is faulty. The firm grants all replacement requests (there is binding legislation) by exchanging faulty products for new ones. For simplicity, replacement units always work well.<sup>10</sup> Let  $c(x)$  be the unitary cost of the product with reliability rate  $x \in [0, 1]$ . We assume  $c(x) > 0$ ,  $c'(x) > 0$ ,  $c''(x) > 0$ , and  $\lim_{x \rightarrow 1} c(x) = +\infty$ . We also assume that  $(1 - x)c(x)$  is weakly decreasing in  $x$ , i.e., the expected cost of manufacturing replacement units is decreasing in the reliability rate.<sup>11</sup>

We first consider the case where  $k$  is uncertain for both the firm and the consumer. They both know  $F$ , but  $k$  realizes only if the product is faulty.<sup>12</sup> In a second case, we assume that each consumer privately knows his claiming cost  $k$  before purchasing and that there are heterogeneous consumers distributed according to  $F$ . We follow a mechanism design approach allowing the firm to screen consumers according to their claiming cost  $k$ .

Throughout the analysis we assume that  $F$  and its changes for comparative static analysis are exogenous. This exogeneity means that we don't allow the firm to explicitly modify  $F$ . This simplification does not prevent us from identifying firm's incentives to modify  $F$ , and we discuss it in Section 4.3.<sup>13</sup>

### 4 Ex-Ante Uncertainty about Claiming Cost $k$

Assume that each consumer does not know his claiming cost  $k$  when deciding whether to purchase the product but he does know the cumulative distribution  $F$ . Then, all consumers behave alike before

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to dissatisfaction (Chebat, Davidow, and Codjovi, 2005; Owens and Hausknecht, 1999).

<sup>9</sup>As in Chen and Hua (2012), we assume that consumers observe the real value of  $x$ . Our results, as in their article, can still be valid when the choice of  $x$  is private information. Suppose, for example, that the firm privately chooses  $x$  but can disclose its value. As long as disclosure costs are small results holds: the firm prefers to disclose its reliability rate in order to avoid being perceived as the lowest quality type. For example, consumer's visual inspection can disclose  $x$ .

<sup>10</sup>Results remain if a replacement itself may fail as well, in which case the consumer may again request a replacement.

<sup>11</sup>These assumptions satisfy technical specifications according to Huang, Liu, and Murthy (2007). The family of functions  $c(x) = \frac{\beta}{(1-x)^\alpha}$ , with  $\alpha \in (0, 1]$  and  $\beta \in \mathbb{R}_{++}$ , satisfies these assumptions.

<sup>12</sup>We can derived the same results in a market with perfect competition. Under perfect competition, firm's problem is replaced by choosing the price  $p$  and the reliability rate  $x$  that maximize consumers' surplus subject to zero profit.

<sup>13</sup>The firm's trade-off of changing consumers' claiming cost can be introduced incorporating a cost of modifying  $F$  (up or downward). This modification requires additional structure generating similar results.

knowing their claiming cost  $k$ . A consumer anticipates that replacing a defective unit is worthy if  $v - k \geq 0$ . Hence, with probability  $F(v)$  his claiming cost  $k$  is lower than  $v$  and, in expectation, he recovers utility  $v - E[k | k \leq v]$ . The ex-ante expected utility of buying  $EU_B$  can be written as

$$EU_B(p, x) = xv + (1 - x)F(v)\left(v - E[k | k \leq v]\right) - p. \quad (1)$$

The consumer pays a price  $p$  in exchange of a unit of the product which works well with probability  $x$ , enjoying a utility of  $v$ , and breaks down with probability  $1 - x$ , requesting a replacement only if  $k \leq v$ . The consumer purchases the product if  $EU_B(p, x) \geq 0$ .

We define the *demand effect* as the effect of increasing reliability on consumer's willingness to pay ( $WTP$ ), that is,

$$\frac{\partial WTP}{\partial x} = v - F(v)\left(v - E[k | k \leq v]\right) = v - \int_0^v F(k)dk. \quad (2)$$

Where  $\int_0^v F(k)dk$  represents the net expected benefit of replacing a defective unit. The demand effect is positive as  $\int_0^v F(k)dk$  ranges within  $[0, v]$ . The higher the  $\int_0^v F(k)dk$ , the lower the demand effect but the higher the consumer's willingness to pay.

The firm's expected cost of selling one unit of the product is  $c(x) + (1 - x)F(v)c(x)$ : the manufacturing cost  $c(x)$  plus the costs associated with a replacement  $c(x)$  when the product fails and the consumer requests a replacement, i.e.,  $(1 - x)F(v)$ .<sup>14</sup> For a given price  $p$  and reliability rate  $x$  the firm's profit of selling is

$$\Pi(p, x) = p - c(x) - (1 - x)F(v)c(x). \quad (3)$$

We define the *replacement effect* as the effect of increasing reliability on the expected cost associated with replacements, that is

$$\frac{\partial}{\partial x}(1 - x)F(v)c(x) = F(v)\left[c(x) - (1 - x)c'(x)\right]. \quad (4)$$

The replacement effect is negative, as we assume that  $(1 - x)c(x)$  decreases in  $x$ . The higher the  $F(v)$ , the higher the replacement effect and the expected unitary cost.

For a non-trivial case, we assume that  $\max_x xv - c(x) > 0$ . The problem of the firm is to maximize  $\Pi(p, x)$  subject to  $EU_B \geq 0$ . From the participation constraint, the price is given by  $p = xv + (1 - x)\int_0^v F(k)dk$ . To determine the reliability rate we replace this price in the profit function and we derive

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<sup>14</sup>Alternatively, the firm may also incur in a per-unit replacement cost  $c_r$  accounting for a variety of costs; from administrative/shipping and handling costs to reputational losses. Additionally, there may exist reputational costs when a product is defective independently of whether there is a replacement. Our results hold as long as  $c_r$  is not too high.

the first order condition.<sup>15</sup>

$$c'(x) = v - \int_0^v F(k)dk + F(v) \left[ c(x) - (1-x)c'(x) \right]. \quad (5)$$

The left hand side is the marginal cost of providing reliability. The right hand side shows the positive effects of providing reliability: increasing the willingness to pay through the *demand effect* and reducing the expected cost of replacement units through the *replacement effect*.

#### 4.1 Comparative Static

In this section we focus on the comparative static of a change in  $F$  on product's reliability and firm's profit. We use the first order stochastic dominance (FOSD) as a criteria for a reduction in consumers' claiming cost, that we denote by  $\succ_1$ . Given  $F_n, F_m$  represents a reduction in consumers' claiming cost if  $F_n \succ_1 F_m$ ; that is,  $F_m(k) \geq F_n(k)$  for all  $k$ , with strict inequality for some  $k$ . Notice that if  $F_n \succ_1 F_m$ , then  $\int_0^{k_0} F_m(k)dk \geq \int_0^{k_0} F_n(k)dk$  for all  $k_0$ .

Now, we can place our main result. There always exists a reduction in consumers' claiming cost that generates a reduction in product's reliability. A reduction in  $F_n$  generates both an increase in the replacement effect as  $F_m(v)$  increases and a decrease in the demand effect as  $\int_0^v F_m(k)dk$  increases. The result holds since for any distribution  $F_n$  there always exists a distribution  $F_m$ , with  $F_n \succ_1 F_m$ , such that the change in the demand effect overcomes the change in the replacement effect.

**Proposition 1.** *Given  $F_n$ , there exists  $F_m$ , with  $F_n \succ_1 F_m$ , such that  $x(m) < x(n)$ .*

Additionally, there always exists a reduction in consumers' claiming cost that generates an increase in firm's profit. A reduction in  $F_n$  increases both consumers' willingness to pay and firm's unitary costs. For any distribution  $F_n$ , there always exists a reduction in consumers' claiming cost that increases consumers' willingness to pay more than firm's unitary cost.

**Proposition 2.** *Given  $F_n$ , there exists  $F_m$ , with  $F_n \succ_1 F_m$ , such that  $\Pi(m) > \Pi(n)$ .*

Given Propositions 1 and 2, Lemma 1 states a relation among these results. Any reduction in consumers' claiming cost that increases profit, it also decreases reliability.

**Lemma 1.** *If a change from  $F_n$  to  $F_m$  generates that  $\Pi(m) > \Pi(n)$ , then  $x(m) < x(n)$ . If a change from  $F_n$  to  $F_m$  generates that  $x(m) > x(n)$ , then  $\Pi(m) < \Pi(n)$ .*

Our results would be more general if consumer's complaining behavior would be efficient. A replacement is efficient if and only if benefits are greater than costs, i.e., if  $v \geq k + c(x)$ . If this was the case, then any reduction in  $F$  would generate a reduction in product reliability and an increase in firm's profit.

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<sup>15</sup>The second order condition is satisfied if  $c(x)$  is sufficiently convex.



However, consumers' complaining behavior is not contractible (by law) and consumers cannot commit to any complaining behavior.

In spite of this lack of commitment/contractability, we can obtain an additional result in the comparative static analysis placing the following assumption over cumulative distributions  $F_n$ .<sup>16</sup>

Assumption 1 -  $E_n[k|k \leq v]$  increases in  $F_n$  for any  $v$ .

Assumption 1 places a particular relation on how the number of claimants  $F_n(v)$  and the expected benefit of requesting a replacement  $\int_0^v F_n(k)dk$  change when there is a reduction in consumers' claiming cost. When consumers' claiming cost is likely to be high, a reduction in it affects  $F_n(v)$  relatively more than  $\int_0^v F_n(k)dk$ . However, additional reductions in consumers' claiming cost increase the impact on  $\int_0^v F_n(k)dk$  relatively to the impact on  $F_n(v)$ .

Assumption 1 guarantees our main results for a wide subset of distributions with monotonic implications. Specifically, there exists a subset of distributions  $F_n$  such that any reduction in consumers' claiming cost generates a reduction in product's reliability. Additionally, the comparative static analysis is monotone on this subset.

**Proposition 3.** *Given Assumption 1. There exists  $F_0$  such that given  $F_n$ , with  $F_0 \succ_1 F_n$ , then any reduction in  $F_n$  generates a decrease in product's reliability.*

Similarly, there exists a subset of distributions such that any reduction in consumers' claiming cost generates an increase in firm's profit, and the comparative static analysis is monotone.

**Proposition 4.** *Given Assumption 1. There exists  $F_1$  such that given  $F_n$ , with  $F_1 \succ_1 F_n$ , then any reduction in  $F_n$  generates an increase in firm's profit (and social welfare).*

We have no general results for distributions above cutoffs  $F_0$  and  $F_1$ . However, it is likely that for high consumers' claiming cost, firm's profit increases and product's reliability decreases as consumers' claiming cost increases. This is the case, for example, when consumers' claiming cost follows an exponential distribution, i.e.,  $F_n(k) = 1 - \exp(-k/n)$  where  $E[k] = n$ ; then product's reliability is an inverted U-shaped function of  $F_n$  and firm's profit is a U-shaped function of  $F_n$ . These relations depend crucially on the lack of consumers commitment/contractability about their claiming behavior.

## 4.2 Welfare

The surplus generated when a consumer buys the product is  $vx - c(x)$ . If additionally this buyer requests a replacement if the product is defective the surplus generated is  $vx - c(x) + (1 - x)(v - k - c(x))$ . When consumers with  $k \leq v$  request a replacement the welfare generated is

$$W(x, k \leq v) = xv - c(x) + (1 - x)F(v) \left( v - c(x) - E[k|k \leq v] \right). \quad (6)$$

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<sup>16</sup>Noting that  $E_n[k|k \leq v] = v - \frac{\int_0^v F_n(k)dk}{F_n(v)}$ , Assumption 1 is equivalent to having that  $\frac{\int_0^v F_n(k)dk}{F_n(v)}$  decreases in  $n$  for any  $v$ .

As this welfare coincides with firm's profit at the equilibrium price, then social and private incentives are perfectly aligned. Consequently, any reduction in consumers' claiming cost that increases profit will also increase welfare.

### 4.3 Some Remarks

We have provided a simple setup pointing out that a reduction in consumers' claiming cost promotes consumer complaints. This increase in complaints may result in either a reduction or an increase in product reliability, firm's profit, and social welfare. Assuming a positive relation between the conditional expected cost of making complaints and consumers' claiming cost (Assumption 1), we claim that consecutive reductions in consumers' claiming cost will, eventually, decrease product's reliability but increase profit and welfare. Consequently, we provide a positive answer to the first question and a negative answer to the second question in the title of this article: we should not worry if a reduction in consumers' claiming cost generates a reduction in product's reliability when this effect is also welfare enhancing.

The anecdotal evidence reveals that a change in consumers' claiming cost can take place either by third parties (consumer agencies, governments, or private enterprises) or firms. We show that, depending on the current  $F_n$ , the firm may have incentives to increase or decrease  $F_n$ . As profit and welfare are aligned, the welfare analysis looks encouraging. If society drives down  $F_n$  through passing consumer's laws and/or promoting and simplifying complaints with new devices, then firms will likely find profitable to cooperate with society by reducing consumers' claiming cost even further.<sup>17</sup> In terms of reliability, the reduction in consumers' claiming cost may motivate an increase in product reliability; however, after consecutive reductions, it is more likely that reliability decreases.

Notice that our results are consistent with the anecdotal evidence. In the last decades, there have been initiatives helping consumers to channel their complaints, generating an increment in the number of complaints. Additionally, more recently, firms started to realize that they can benefit from simplifying consumer complaints through an increase in consumers' willingness to pay. In this line, firms may need to look for commitment and credibility. One way of doing so is through outsourcing consumer requests to on-line platforms, which have increased notoriously in the last decades.

## 5 Asymmetric Information about Claiming Cost $k$ (Price Discrimination)

We assume now that each consumer privately knows his claiming cost  $k$  before deciding whether to purchase or not and that there are heterogeneous consumers according to a known cumulative distribution  $F$ . The cumulative distribution  $F$  is assumed to be differentiable, with log-concave density function  $f$ .

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<sup>17</sup>Firms may also propose a mean-preserving spread of  $F$ . For example, if substituting the complaining system for an easier procedure but which is available only through fidelity programs, a firm simplifies complaining to loyal consumers and entangles it to non-loyal consumers.

A consumer with claiming cost  $k$  pursues a replacement if  $v - k \geq 0$  when the product acquired is faulty, where  $k$  defines the consumer's type. Consequently, each type- $k$  consumer purchases one unit of the product at price  $p$  and reliability  $x$  if

$$EU_B(p, x; k) = xv + (1 - x) \max\{v - k, 0\} - p \geq 0.$$

Notice that the  $EU_B$  increases in  $x$ , decreases in  $k$  and satisfies the single crossing condition.

The firm maximizes her profit designing a set of menus defined by prices and reliabilities, anticipating consumers' complaining behavior. As some consumers choose not to complain, the firm recognizes claimants and non-claimants among consumers. All consumers with  $k > v$  are non-claimants. Considering the mechanism design approach, a menu  $\{p(k), x(k)\}$  for buyer of type  $k$  must satisfy the incentive compatibility (IC) and the individual rationality (IR) constraints. As the expected utility of buying decreases with consumer's type  $k$ , the Virtual Surplus may be negative for some consumers and the firm may prefer to exclude these consumers from purchasing the product. Consequently, the firm also considers an exclusion condition (EX) for those consumers that will not purchase the product.

The problem of the firm can be expressed as follows,

$$\begin{aligned} \max_{\{p(k), x(k), I_B(k)\}} & \int_0^v \left[ p(k) - c(x(k)) - (1 - x(k)) c(x(k)) \right] I_B(k) dF(k) \\ & + \int_v^{+\infty} \left[ p(k) - c(x(k)) \right] I_B(k) dF(k), \\ \text{subject to} & \quad k \in \arg \max_{k'} EU_B(k, p(k'), x(k')), \quad (\text{IC}), \\ & \quad EU_B(p(k), x(k), k) \geq 0, \quad \text{if } I_B(k) = 1, \quad (\text{IR}), \\ & \quad EU_B(p(k), x(k), k) \leq 0, \quad \text{if } I_B(k) = 0, \quad (\text{EX}), \end{aligned} \quad (7)$$

where  $I_B(k)$  takes the value of one if the consumer with claiming cost  $k$  buys the product with menu  $\{p(k), x(k)\}$  and zero otherwise.

As pointed out in Section 4, consumers complaining behavior is not contractible (e.g., by law) and consumers cannot commit to a particular behavior, generating a non-monotonic Virtual Surplus for the firm. Consequently the firm may prefer to bunch some consumers. To see this, notice that if only efficient replacements were requested by consumers, consumers' willingness to pay and firm's unitary costs would be discontinuous at  $k = v - c(x)$ , decreasing from  $vx + (1 - x)c(x)$  to  $vx$  and from  $c(x) + (1 - x)c(x)$  to  $c(x)$ , respectively. As these discontinuities compensate each other, Surplus and Virtual Surplus would be continuous. However, consumers' replacement decisions are not contractible and each consumer requests a replacement of a defective unit when  $k \leq v$ . Consequently, consumers' willingness to pay is continuous in  $k$  but unitary cost, and thus Surplus and Virtual Surplus, are discontinuous at  $k = v$ . Unitary cost decreases from  $c(x) + (1 - x)c(x)$  to  $c(x)$  and Surplus increases from  $vx - c(x) - (1 - x)c(x)$  to  $vx - c(x)$ .

As in Mussa and Rosen (1978), Lewis and Sappington (1989), and Jullien (2000), the solution to the firm's Problem 7 is characterized by one of two possible strategies, one with bunching and full participation and one without bunching but excluding some consumers from purchasing. We label the former the *bunching strategy* and the latter the *exclusion strategy*. We have a difference with those articles. In our model the bunching case arises endogenously due to consumers' inefficient complaining behavior, even when the problem satisfies regular conditions.<sup>18</sup>

Given our assumptions, we can generally apply the first order approach. When following an *exclusion strategy*, the firm chooses a marginal consumer  $\bar{k}$  ( $< v$ ), that is  $I_B(k) = 1$  if  $k \leq \bar{k}$  and  $I_B(k) = 0$  otherwise. The IC constraints define prices and informational rents,  $p(k) = v - (1 - x(k))k - \int_k^{\bar{k}} (1 - x(t))dt - U(\bar{k})$ . Replacing these prices into the profit function and noticing that  $U(\bar{k}) = 0$  (no rents to the marginal buyer), the firm's problem becomes

$$\max_{x(k), \bar{k}} \int_0^{\bar{k}} \left( v - (1 - x(k)) \left( k + \frac{F(k)}{f(k)} \right) - c(x(k)) - (1 - x(k))c(x(k)) \right) f(k) dk.$$

The firm chooses reliability  $x(k)$  according to the Virtual Surplus of consumer  $k$  (depending on  $k + \frac{F(k)}{f(k)}$ ), minimizing the informational rents. From the first order condition respect to  $x(k)$  we have

$$c'(x) = c(x) - c'(x)(1 - x) + k + \frac{F(k)}{f(k)}. \quad (8)$$

The left hand side represents the marginal cost of providing reliability. The right hand side shows the marginal benefits of providing reliability, as defined in Section 4.<sup>19</sup> The first two terms on the right hand side represent the reduction in replacement costs (*replacement effect*). The expression  $k + \frac{F(k)}{f(k)}$  represents the *virtual demand effect* of consumer  $k$ ; increasing reliability, the firm charges higher prices. The solution  $x(k)$  increases in  $k$  and  $\frac{F(k)}{f(k)}$ . The marginal consumer  $\bar{k}$  is characterized by equalizing the Virtual Surplus to zero,

$$v - (1 - x(\bar{k})) \left( \bar{k} + \frac{F_n(\bar{k})}{f_n(\bar{k})} \right) - c(x(\bar{k})) - (1 - x(\bar{k}))c(x(\bar{k})) = 0.$$

When the firm follows a *bunching strategy* all consumers buy the product, i.e.,  $I_B(k) = 1$  for all  $k$ . The firm chooses a cutoff consumer  $\tilde{k}$ , bunching all consumers with  $k \geq \tilde{k}$ .<sup>20</sup> All consumers with  $k < \tilde{k}$  are screened and their prices are defined by the IC constraints,  $p(k) = v - (1 - x(k))k - \int_k^{\tilde{k}} (1 - x(t))dt - U(\tilde{k})$ . Notice that each of these consumers receives an additional informational rent equal to  $U(\tilde{k}) = (1 - \tilde{x})(v - \tilde{k})$  (the lowest screened type- $\tilde{k}$  utility), implying lower prices than under an *exclusion strategy*. Bunched consumers, instead, receive the same menu with price  $p = \tilde{x}v$ . The firm's problem

<sup>18</sup>The regular conditions are monotone reverse hazard rate (guaranteed by log-concavity of  $F$ ), single crossing condition, and homogeneous reservation utility.

<sup>19</sup>Comparing with Equation 5, write Eq. 8 as  $c'(x) = v - \left( v - k - \frac{F(k)}{f(k)} \right) + (c(x) - (1 - x)c'(x))$ .

<sup>20</sup>All consumers with  $k \geq v$  are trivially bunched. The bunching strategy characterizes those consumers with  $k \leq v$  that are bunched instead of screened.

becomes

$$\begin{aligned} & \max_{x(k), \tilde{k}} \int_0^{\tilde{k}} \left( v - (1 - x(k)) \left( k + \frac{F_n(k)}{f_n(k)} \right) - c(x(k)) - (1 - x(k))c(x(k)) \right) f_n(k) dk, \\ & - (1 - \tilde{x})[v - \tilde{k}]F_n(\tilde{k}) + [F_n(v) - F_n(\tilde{k})](\tilde{x}v - c(\tilde{x}) - (1 - \tilde{x})c(\tilde{x})) + [1 - F_n(v)](\tilde{x}v - c(\tilde{x})). \end{aligned}$$

The first and second terms represent the aggregate Virtual Surplus; the third term represents the surplus from those bunched consumers who request replacements when the product is faulty; and the fourth term represents the surplus from those bunched consumers who never request replacements. Notice that the second term is the aggregate informational rents to avoid that consumers with  $k \in [0, \tilde{k}]$  choose the menu of the bunched consumers. The firm chooses reliabilities  $x(k)$  of screened consumers according to Equation (8). Bunched consumers, instead, receive the same reliability rate  $\tilde{x}$  defined by,

$$\underbrace{[1 - F(v)](v - c'(x))}_{\text{demand effect}} + \underbrace{[F(v) - F(\tilde{k})](v - c'(x)(2 - x) + c(x))}_{\text{demand and replacement effects}} + \underbrace{F(\tilde{k})(v - \tilde{k})}_{\Delta \text{ info rents}} = 0. \quad (9)$$

The first two terms in Equation (9) incorporate the positive demand and replacement effects of providing costly reliability, as in Equation (8). The third term is new and incorporates the weight of the additional informational rents paid to the screened consumers. The firm increases product's reliability in order to reduce the additional aggregate informational rents defined by  $F(\tilde{k})U(\tilde{k}) = F(\tilde{k})(1 - \tilde{x})(v - \tilde{k})$ . The firm defines the cutoff buyer  $\tilde{k}$  by being indifferent between screening and pooling (bunching) this cutoff buyer. Defining  $\tilde{x}$  the bunching reliability rate and  $\hat{x} := x(\tilde{k})$  the reliability rate of the cutoff consumer  $\tilde{k}$  is screened (defined by Equation (8)). The cutoff consumer  $\tilde{k}$  is characterized by

$$v - (1 - \tilde{x}) \left( \tilde{k} + \frac{F_n(\tilde{k})}{f_n(\tilde{k})} \right) - c(\tilde{x}) - (1 - \tilde{x})c(\tilde{x}) - (1 - \hat{x})(v - \tilde{k}) = v\hat{x} - c(\hat{x}) - (1 - \hat{x})c(\hat{x}).$$

Notice that this mark-up can be positive or negative.<sup>21</sup>

## 5.1 Comparative Static

We now use the reverse hazard rate ordering as a criteria for a reduction in consumers' claiming cost, that we denote by  $\succ_2$ . Given  $F_n$ ,  $F_m$  represents a reduction in consumers' claiming cost if  $F_n \succ_2 F_m$ , that is if  $\frac{F_m(k)}{f_m(k)} \geq \frac{F_n(k)}{f_n(k)}$  for all  $k$ , with strict inequality for some  $k$ . This ordering  $\succ_2$  is stronger than  $\succ_1$ : if  $F_n \succ_2 F_m$ , then  $F_n \succ_1 F_m$ .

The reverse hazard rate ordering of distributions guarantees that the firm follows an exclusion strategy when consumers' claiming cost is low enough and a bunching strategy when consumers' claiming cost is high enough. Additionally, firm's profit increases as consumers' claiming cost decreases when following an exclusion strategy. Let  $\Pi_B$  be the profit when the firm follows a bunching strategy and  $\Pi_E$  be the

<sup>21</sup>If  $1 - F(v)$  is sufficiently high, the firm may prefer to follow a bunching strategy even when the mark-up of those consumers with  $k \in [\tilde{k}, v]$  is negative.

profit when the firm follows an exclusion strategy.

**Proposition 5.** *There exists a cutoff distribution  $F_2$  such  $\Pi_E(F_n) \geq \Pi_B(F_n)$  for any  $F_n$  such that  $F_2 \succ_2 F_n$ , and  $\Pi_B(F_n) > \Pi_E(F_n)$  for any  $F_n$  such that  $F_n \succ_2 F_2$ . Additionally, for any  $F_n$  such that  $F_2 \succ_2 F_n$ ,  $\Pi_E(F_n)$  increases if  $F_n$  decreases.*

We do not have general comparative static results for  $F_n$  above the cutoff  $F_2$ . We observe that under some families of distributions, firm's profit increases as consumers' claiming cost increases when  $F_n$  satisfies  $F_n \succ_2 F_2$ ; that is, if consumers' claiming cost is high, the firm prefers to increase consumers' claiming cost to reduce the replacement effect. Notice, again, that this result is due to the consumers' inefficient complaining behavior

Our main result about reliability extends in the following way: for any type- $k$  consumer, the reliability rate  $x(k)$  increases when  $F_n$  decreases, but the average reliability rate in the market eventually decreases. That is, product reliability increases for any type  $k$  after a reduction in consumers' claiming cost. However, since the distribution  $F_n$  has moved to the left, there are fewer consumers with type- $k$  and more of consumers with lower  $k$  who buy less reliable products; additionally, the marginal consumer  $\bar{k}$  is smaller. In the extreme case, where  $F_m(k=0) = 1$ , the reliability rate  $x_m(k=0)$  is the lowest. Consequently, the average reliability rate eventually decreases. The average reliability with  $F_n$  and the marginal consumer  $\bar{k}$  is defined as  $E_n[x(k)] := \frac{1}{F_n(\bar{k})} \int_0^{\bar{k}} x(k) dF_n(k)$ .

**Proposition 6.** *For any  $F_n$ , there exists  $F_m$ , with  $F_n \succ_2 F_m$ , such that  $E_m[x(k)] < E_n[x(k)]$ .*

For some particular distributions, like the exponential distribution, the average reliability has an inverted U-shaped with respect to  $F_n$ . When the firm follows a bunching strategy, the average reliability increases as consumers' claiming cost decreases; when the firm follows an exclusion strategy, the average reliability decreases as consumers' claiming cost decreases.

## 5.2 Welfare

The surplus generated when a consumer with claiming cost  $k$  buys a product with reliability  $x$  is  $vx - c(x)$ . If additionally this consumer requests a replacement the surplus generated is  $vx - c(x) + (1-x)(v - c(x) - k)$ .<sup>22</sup>

For the welfare analysis we point out the two elements of inefficiency: first, consumers may have an inefficient complaining behavior; and second, firm's asymmetric information problem generates an additional distortion in the allocation of reliability and the exclusion of some consumers from purchasing. Both of these inefficiencies are affected when consumers' claiming cost decreases. However, when the firm follows an exclusion strategy, firm's profit and social welfare are partially aligned, and both increase

<sup>22</sup>We do not analyze the over or under provision of reliability, but in line with Spence (1975) and Lewis and Sappington (1989) the firm has incentives to (almost always) overprovide reliability. Then, any reduction in consumers' claiming cost that reduces the overprovision may increase welfare.

as consumers' claiming cost decreases.

### 5.3 Remarks on the Price Discrimination Case

We see this extension of the model as a particular application of Johnson and Myatt (2006). Notice that the bunching strategy resembles a massive-market strategy selling to all consumers and the exclusion strategy resembles a niche-market strategy selling only to consumers with high willingness to pay. In this setup, firm's profit is convex in  $F_n$ . A change in  $F_n$  modifies demand generating a rotation of the unitary markups distribution which motivates the firm to change from a bunching strategy to an exclusion strategy. Particularly, a reduction in  $F_n$  not only motivates the change of strategy, but also provides incentives to the firm to encourage consumer complaints.

Additionally, when the firm follows an exclusion strategy, profit and social welfare are partially aligned, and they both increase when there is a reduction in consumers' claiming cost. In general, reducing consumers' claiming cost may increase or decrease social welfare and profit, but additional reductions in consumers' claiming cost will motivate the firm to follow an exclusion strategy. Consequently, social and private incentives will be partially aligned. Additionally, the firm will have incentives to simplify consumer complaints even further in order to increase profit, and thus it will increase social welfare as well. Moreover, these interventions may also reduce the average product reliability.

## 6 Robustness

Our results also hold under different specifications: when replacements are not always granted; when reliability depends on ex-ante expenditures in product design; when consumers are heterogeneous in their claiming costs and/or in their valuations; and when these dimensions are correlated.

We assume that replacements are always granted. Assuming that, when requested, a replacement takes place with probability  $z < 1$  does not change our results. Suppose that a firm can affect both consumers' claiming cost and the probability of replacement. Then if profit increases when reducing consumers' claiming cost it will also increase when increasing the probability of replacing defected units.

We assume that it is more expensive to manufacture a more reliable product, i.e.,  $c'(x) > 0$ . Our results also hold if we assume that, instead, the firm invests in product design (e.g., R&D) to develop a more reliable product whereas its manufacturing cost is constant for any reliability rate, e.g., an innovation about how to assemble the product. A new effect arises: product design expenditures are a sunk cost, thus the per unit sunk cost is lower when demand is higher. It is enough to assume that product design expenditures are increasing and convex in product reliability for our results to hold.

In the model we assume that consumers' valuations are the same across them. In the market, consumers may be heterogeneous in their valuations and their claiming costs. These two dimensions may

also be correlated. For instance, a consumer with higher income may have both higher valuation for a product and higher opportunity cost of time (which is necessary to request a replacement). We consider both cases: where valuations and claiming costs are heterogeneous but independent among consumers; and where these two dimensions are perfectly correlated, i.e., the claiming cost is a fixed proportion of consumer's valuation, and our results still hold. The case with correlation seems a reasonably upper bound for three reasons. First, the time to request is proportional to the total endowment of time for consumers. Secondly, consumers with higher income can buy another individual's time or a legal insurance to handle with these complaints.<sup>23</sup> Finally, note that wealth and education are positively correlated. Well-educated individuals usually know better the legal procedure to make a complaint than less educated consumers, implying that these consumers may complain incurring in less time than consumers with lower income.

## 7 Conclusion

This article studies how consumers' claiming cost affects product's reliability and firm's profit. Under general conditions we show that product's reliability may decrease and firm's profit may increase when consumers' claiming cost decreases.

The main warning of this article is about welfare implications. Promoting complaints may reduce welfare and profit. Firms, however, on their own interest, will encourage even further consumer complaints and eventually will increase welfare and profit. Then, we conclude that if any social effort is allocated to help consumers it should be focused on encouraging consumer complaints. Afterwards, firms will voluntarily be in charge of simplifying these complaints even further.

Consumers' associations goals are, among others, to help consumers voice their complaints and enforce the provision of reliable products. In this article, we show that these goals may not be aligned: the firm may decide to produce a less reliable product if more consumers request a replacement of a defective product. This effect, however, should not worry consumer associations and consumer agencies (public or private) as we showed that these effects are welfare improving.

Last, but not least, as it is getting easier to complain for consumers and many companies are turning to encourage consumers to complain, the market may provide ideal situations to test our results.

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<sup>23</sup>For instance, a consumer association can provide a consumer help service for a monthly fee. They have a thorough legal knowledge and experience and they can lobby firms to enforce a consumer request.



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## A Appendix: Proof of Propositions 1, 2, 3, and 4

*Propositions 1 and 2.* We first notice that a change from  $F_n$  to  $F_m$  generates a decrease in product reliability if and only if

$$\int_0^v F_m(k) - F_n(k) \, dk > (F_m(v) - F_n(v)) \left[ c(x(n)) - (1-x)c'(x(n)) \right], \quad (10)$$

where  $x(n)$  is the firm’s choice of reliability when  $F_n$ ; and it generates an increase in firm’s profit if and only if

$$\int_0^v F_m(k) - F_n(k) \, dk > (F_m(v) - F_n(v)) c(x(n)). \quad (11)$$

For any  $F_n$ , we can trivially propose  $F_m$  such that  $F_m(k) = F_n(k) + \varepsilon$  for all  $k$ . The Condition (10) becomes  $v\varepsilon > \varepsilon \left[ c(x(n)) - (1-x)c'(x(n)) \right]$  which always holds and  $x(m) < x(n)$ . Similarly, Condition (11) also holds and  $\Pi(m) > \Pi(n)$ .  $\square$

*Propositions 3 and 4.* We prove Proposition 3, the other follows the same logic. The profit function can be expressed as  $\Pi_n(x) = xv - c(x) + (1-x)F_n(v)[v - E_n[k|k \leq v] - c(x)]$ . There always exists  $F_0 \in \mathbf{F}$  such that  $E_0[k|k \leq v] = v - c(x)$ . A change from  $F_n$  to  $F_m$  with  $F_0 \succ_1 F_n \succ_1 F_m$  generates a reduction in profit if

$$\begin{aligned} F_m(v)[v - E_m[k|k \leq v] - c(x)] &> F_n(v)[v - E_n[k|k \leq v] - c(x)], \text{ or} \\ [F_m(v) - F_n(v)][v - c(x)] &> F_m(v)E_m[k|k \leq v] - F_n(v)E_n[k|k \leq v]. \end{aligned}$$

Since  $E_m[k|k \leq v] < E_n[k|k \leq v]$ , then the condition holds if  $[v - c(x)] > E_m[k|k \leq v]$ ; and this last inequality holds by Assumption 1.  $\square$

## B Appendix: Proof of Propositions 5 and 6

*Proposition 5.* Notice that for any  $F$  the firm must choose between non-bunching, extracting surplus from those consumers with low claiming cost, and bunching, extracting surplus from all consumers but mainly from those consumers with  $k > v$ .

Under a bunching strategy, the firm find the highest markups from those consumers with  $k \in [0, \tilde{k}]$  and with  $k \in [v, +\infty)$  and the lowest markups from those consumers with  $k \in (\tilde{k}, v]$  which may be negative.

Any reduction in  $F_n$  increases the number of consumers with  $k \in [0, \tilde{k}]$  and with  $k \in (\tilde{k}, v]$ . Suppose that the optimal firm's strategy with the new distribution  $F_m$  is to bunch consumers, then necessarily the firm also prefers the bunching strategy in the original distribution  $F_n$ .

Suppose not, that is, with  $F_n$  the firm follows a non-bunching strategy. This means that the mark-up from those consumers with low  $k$  is so high that overcome the markups extracted from those consumers with  $k \in [v, +\infty)$ . If this is the case, with  $F_m$  must follow a non-bunching strategy because there are more consumers with low  $k$  and less consumers with high  $k$ .

If the firm follows a non-bunching strategy for a particular  $F$ , then the firm follows a non-bunching strategy for any reduction in  $F$ . If the firm follows a bunching strategy for a particular  $F$ , then the firm follows a bunching strategy for any increase in  $F$ .  $\square$

*Proposition 6.* The proof is direct because the cumulative distribution  $F_m$  with lowest claiming costs, that is  $F_m(k) = 1 \forall k \in [0, +\infty)$ , generates the lowest reliability rate.  $\square$